PERIPHERAL CIRCULATION FOR LOW-COST CENTRAL HEATING IN OLD HOUSES

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PERIPHERAL CIRCULATION FOR LOW-COST CENTRAL HEATING IN OLD HOUSES

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INTRODUCTION

Satisfactory central heating with low-cost, even distribution may be provided to new houses by the peripheral circulation system. The system is simple to install and operate. It utilizes all sources of heat in the house, keeps all the air in the house in constant motion, eliminates stagnant or dead air pockets and stratification, and maintains even temperature throughout the house. This is a report on the installation and use of this system in an existing house with a shallow crawl space.

A peripheral circulation system forces all the air in the house to move in a definite pattern (fig. 1). A blower pulls air from all parts of the house into a centrally located duct near the ceiling. This air is mixed in the duct to a uniform temperature and forced into a plenum or crawl space that serves as a duct, carrying the air to any desired point under the floor. A continuous slot or a series of holes along the entire outside wall allows the air to escape from the plenum through the floor and back

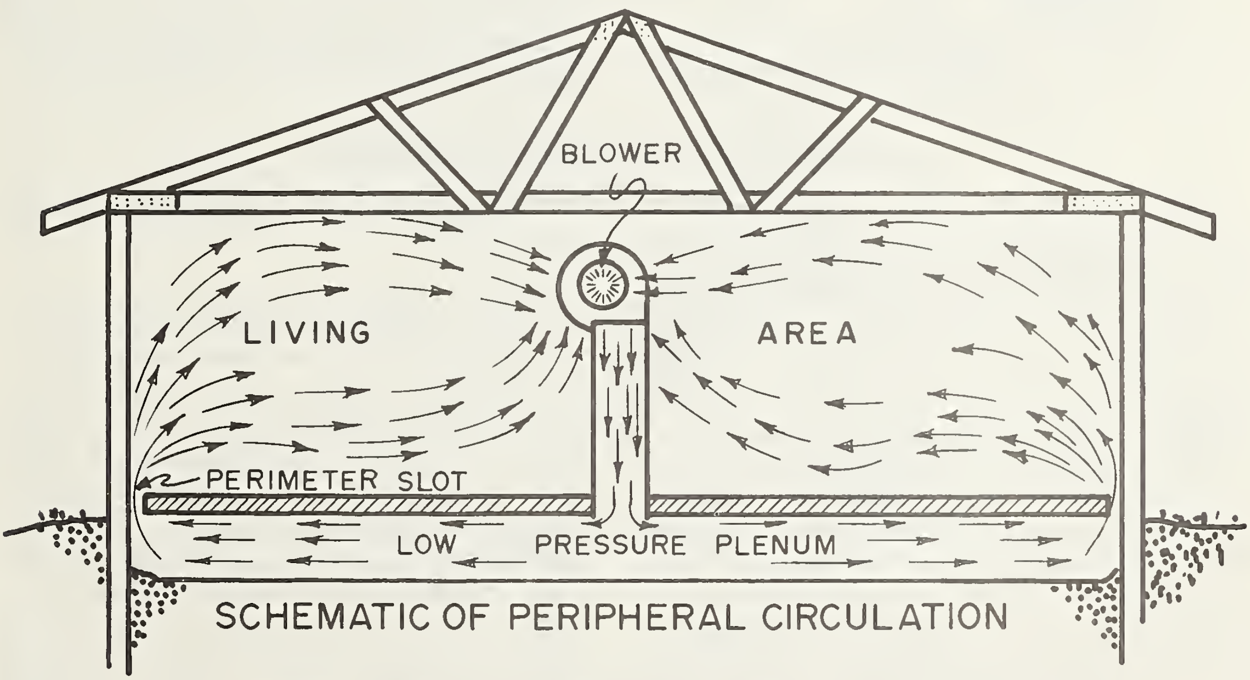

FIGURE 1.—Pattern of air movement in a peripheral circulation system.

into the living area. A thin film of air flows up along the outside wall and gradually moves toward the central duct for remixing and redistribution.

Heat produced in any part of the house raises the temperature of the surrounding air. The hot and cold air from all parts of the house are mixed together at the central duct to an average temperature, then returned to all parts of the house. The flexibility of peripheral circulation allows many different combinations of the aforementioned assets. Among the various kinds of heat-producing equipment are a potbellied stove, a furnace, baseboard heaters, or radiant panels. Heat from cooking, light bulbs, and electric motors is also uniformly distributed.

The criteria for home heating vary. What one person likes may be very objectionable to another. Even the most antiquated heating systems are preferred by some. Features of good heating proclaimed by many and strived for here are:

1. Uniform temperature distribution.
2. A hotspot for quick warmup.
3. Economy of operation.
4. Dependability of operation.
5. Low initial cost.
6. Cleanliness.
7. Independent operation.

In most heating systems, some of these features are sacrificed for others. In an effort to achieve as many of these features as possible, several installations utilizing the peripheral circulation distribution system have been studied in the past few years.

Most installations of peripheral circulation have been in new houses; however, most heating problems occur in older houses. Because of the low cost of installing peripheral circulation and because of the predominance of old homes among low-income families, the possibility of adding peripheral circulation to existing heating systems is under investigation.

Because tests in new houses have shown that peripheral circulation can maintain uniform temperatures with simple heating equipment, it was believed that this system could be effective in older houses. It was also believed that in many houses the materials for the installation could be obtained for less than $100.

In order to properly evaluate the feasibility of adding peripheral circulation to an older house, a search was made to locate a house without central heating that would be suitable for such an installation.

A house located at Blacksburg, Va., was selected for the installation because of its Appalachian location and the desire of several Virginia Polytechnic Institute staff members who were interested in peripheral circulation heating systems to assist in the experiment.

DESCRIPTION OF THE TESTHOUSE

The house selected is wood framed, with lap siding and drywall interior surfaces (fig. 2). The L-shaped floor plan of this three-bedroom house is shown in figure 3. The total floor area is 856 square feet. The floors are hardwood over plywood on 2- by 8-inch floor joists, and the roof is constructed of standard rafters with plywood sheathing and 235-pound shingles.

The foundation is concrete blocks to which sills are anchored with ½-inch bolts. There is a crawl space 12 to 24 inches deep under the entire house. The house is insulated with Fiberglas—2 inches thick in the sidewalls and 4 inches thick in the ceiling. Before the installation, there was no vapor barrier to control the flow of moisture from the house into the walls nor from the ground to the crawl space. The windows are woodframed and double-hung with a single thickness of glass. Some also have a storm sash.

House Condition When Peripheral Circulation Heat Was Installed

In general, the paint on this 4-year-old house was in good condition except for the lower siding boards that extended below the floor level. The paint on these boards had blistered and peeled considerably, as shown in figure 4. This damage indicated that moisture was migrating from the crawl space through the lap siding. Because the moisture could not pass through the paint film, it condensed under the paint and caused the paint to loosen. Gradually more and more moisture collected under the paint film, pushing it away from the board.

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FIGURE 2.—Testhouse located at Blacksburg, Va. Peripheral circulation was added to the existing system to distribute the heat from the 65,000-B.t.u./hr. specifications already in use.

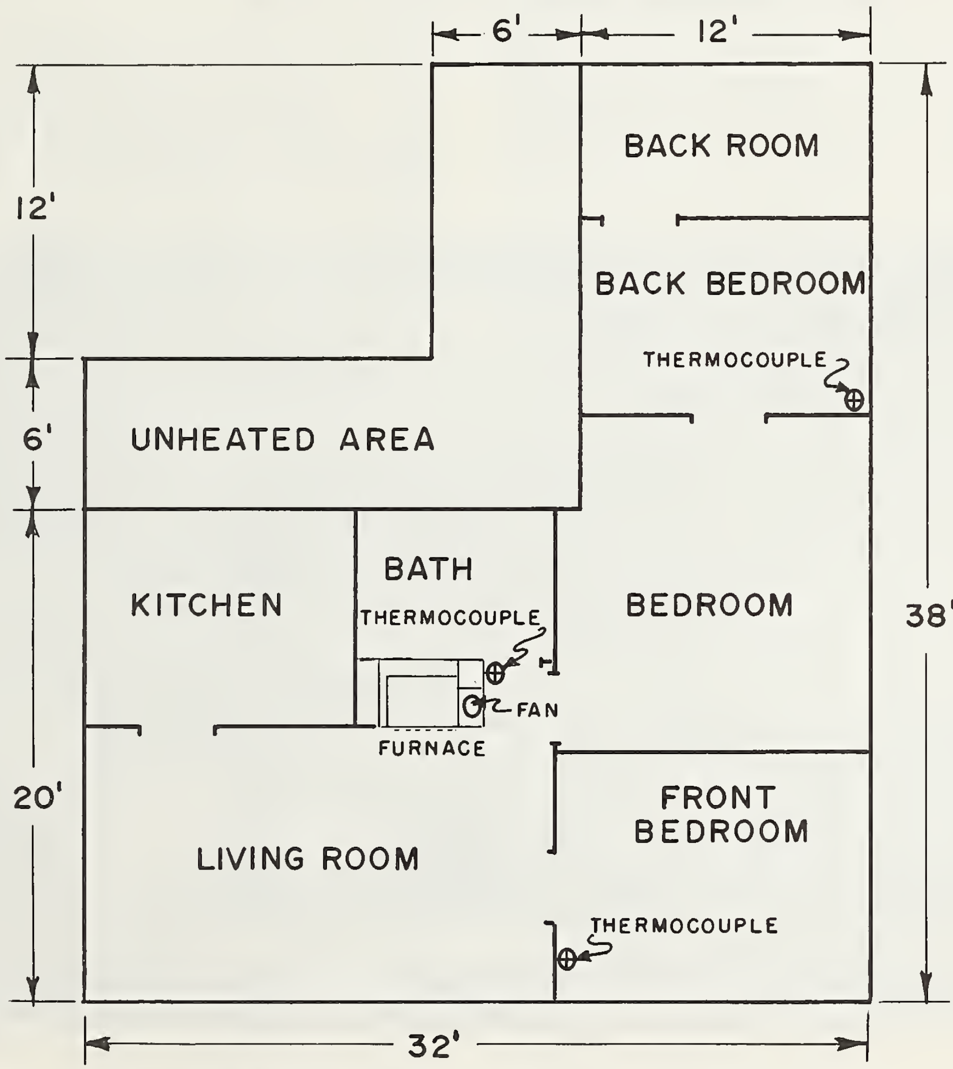

FIGURE 3.—Floor plan of testhouse at Blacksburg, Va., showing location of temperature-sensing thermocouples.

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FIGURE 4.—Moisture migrating from crawl space had condensed under paint and caused blisters.

The heating system was converted the first week of January 1968. The house had not been occupied for several days, but the living room space heater was operating. Outside temperatures ranged from 4° F. to 32° over a 5-day period during the conversion and just before photographs were taken under the floor (figs. 5 and 10).

The house had a musty odor, which indicated the growth of fungi and mold. There was some evidence of the foundation settling, and some of the doors did not swing level.

Under the house the ground was muddy, and under the back bedroom frost had formed on the joists and headers adjacent to the outside wall (2 feet around perimeter). Water had condensed and was dripping from the headers under the front bedroom. Mold or fungi was evident on all floor joists under the back bedroom, especially on those timbers within 2 feet of the outside wall. Some of the timbers were rotten (fig. 5). Floor joists under the back bedroom contained as much as 49-percent moisture.

The crawl space did have vents in the foundation wall, but most of them were not open. In some places the grade along the house was sloped toward the structure (fig. 6).

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FIGURE 5.—Rotten floor joists caused by excessive moisture in crawl space.

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FIGURE 6.—The grade sloped toward the house, causing water to flow along and seep into crawl space.

Existing Heating System

The house was heated with a 65,000 B.t.u./hr. oilstove that was recessed in the center wall of the living room in a metal-lined compartment (fig. 7). The burner operated from a high flame to a low flame by the signal from the wall-mounted thermostat. A small fan was mounted in the stove compartment and thermostatically controlled to prevent overheating of the stove; it created a turbulence in the compartment but was not large enough to distribute air throughout the house.

A grill at the top of the stove allowed hot air to escape from the metal-lined compartment, and a similar grill below allowed cool air to enter the compartment. There was no positive air movement in the house, and heat was distributed by the natural forces of convection.

Physical Considerations

In selecting the house, the problem of adding peripheral circulation was discussed. The settling floor, the rotting floor joists, and the peeling paint indicated that the structure was damaged; however, it was believed that this damage could be corrected satisfactorily at reasonable cost. Since the grade around the house did not adequately divert the water from the foundation wall, additional grading was desirable.

Cracks along the top of the foundation wall and at other points in the crawl space would allow considerable air leakage should the chamber be used as a pressurized plenum for air distribution. This air leakage could be reduced by calking these cracks or by installing some type of seal on the crawl space wall. Calking was selected as the most expedient method.

The uninsulated foundation wall would allow considerable heat loss by conduction. The wall could be insulated by covering it with pressed fiberboard or other insulating material. Because of the shortage of labor and time, insulation could be delayed for the first season and the extra heating cost absorbed.

The next problem was to find a suitable spot for a central duct. A small built-in bookcase containing several shelves was located beside the wall stove near the center of the house (fig. 8). The shelves could be removed to allow the central duct to be installed. The blower could be mounted at the floor level in the duct, at the top of the duct, or in the crawl space. The most suitable place, and that selected in this house, was at the floor level where the duct could be enlarged to accommodate the blower. The shallow crawl space was not selected because it would be difficult to service the fan. Locating the fan at the top of the duct would cause excessive vibration and noise.

In new houses a slot is formed around the

outside walls during construction, but a suitable air return had to be developed for this testhouse. Care was required to avoid unsightly or expensive construction.

After studying all these conditions, it was decided to install the system as follows: Shelves were removed from the bookcase in the living room, and an opening was prepared in the floor at its base. Then rubber mounts were installed to support the fan and to reduce vibration. A 1,200-cubic-feet-per-minute blower was installed over the opening in the floor and provided with electric power. Except for the 144-sq.-in. air intake at the top, the front of the bookcase was enclosed to develop a chamber around the fan and to form the central duct. A 77-sq.-in. opening was made between the top of the central duct and the stove cabinet to form a short circuit duct to allow the hot air to enter directly into the distribution chamber. The crawl space wall was sealed by calking all cracks, and a plastic vapor barrier was spread over the soil. In the living area the shoe molding was removed along all outside walls, and ¾-inch holes were drilled 4 inches on center under the shoe molding. Then the shoe molding was blocked up one-eighth of an inch and nailed in place (fig. 9).

This entire conversion required 21.5 hours of unskilled labor and $44 in materials.

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FIGURE 7.—Wall stove, which was the original heating system.

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FIGURE 8.—Central duct and fan installation.

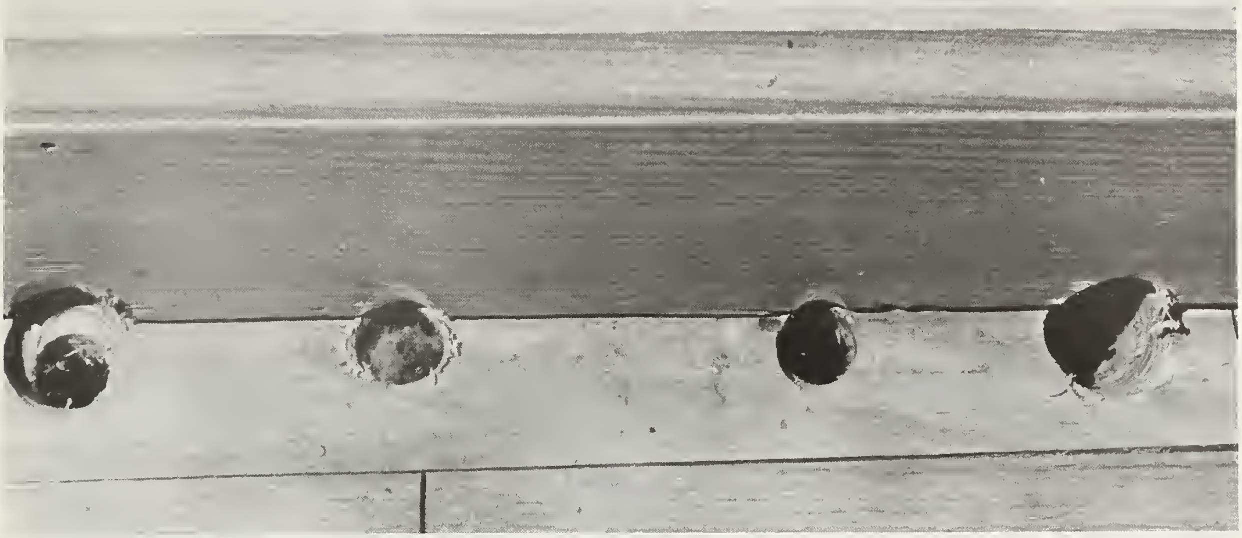

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FIGURE 9.—Three-quarter-inch holes drilled under baseboard through the floor.

TEST SCHEDULE FOR RECORDING ENVIRONMENTAL AND PHYSICAL CONDITIONS IN THE TESTHOUSE

I. Before circulation is started:
   A. Record moisture content of—
      1. floor joist
      2. floor
      3. center beam
      4. sill
      5. sill header
   B. Record humidity in plenum and living area.
   C. Record temperature patterns throughout the house at one point at least in each room and at three elevations at each point.

II. After circulation is started:
   A. Until conditions stabilize record moisture content three to seven times per week of—
      1. floor joist
      2. floor
      3. center beam
      4. sill
      5. sill header
   B. Keep continuous record of relative humidity in crawl space and in certain rooms until conditions stabilize.
   C. Keep continuous record of temperatures at four locations throughout the house and at three elevations at each location.
   D. Record occupant reaction.
   E. Keep continuous record of temperature under house.

Instrumentation

To measure the effect of peripheral circulation on the house:

1. A hydrothermograph was installed in the crawl space several days before the circulating blower was started. The hydrothermograph was a circular chart, continuous recording type that makes one rotation each day. This instrument was operated after the blower operation started until the relative humidity stabilized under the house.

2. An instrument that records relative humidity on a strip chart was installed in the living area. Recordings were made until conditions stabilized.

3. Temperatures throughout the house were recorded by a 12-point continuous recording

potentiometer, which utilized copper constantan thermocouple sensing elements. Sensing elements were placed at three locations in the house (fig. 3) and at three different elevations (4, 48, and 90 inches above the floor).

4. An electrical resistance moisture meter was used to measure the moisture content of the framing timbers of the floor (fig. 10). Several points were selected under the house to measure the moisture contents at regular intervals.

RESULTS

Temperature Uniformity Test

Figure 11 shows a record of the temperatures in the house before, during, and after the peripheral circulation was installed.

Before the blower was started, the back bedroom temperature was quite low. Near the floor, temperatures of 40° F. were not uncommon when outside temperatures were below 20°. Temperatures near the ceiling of the living

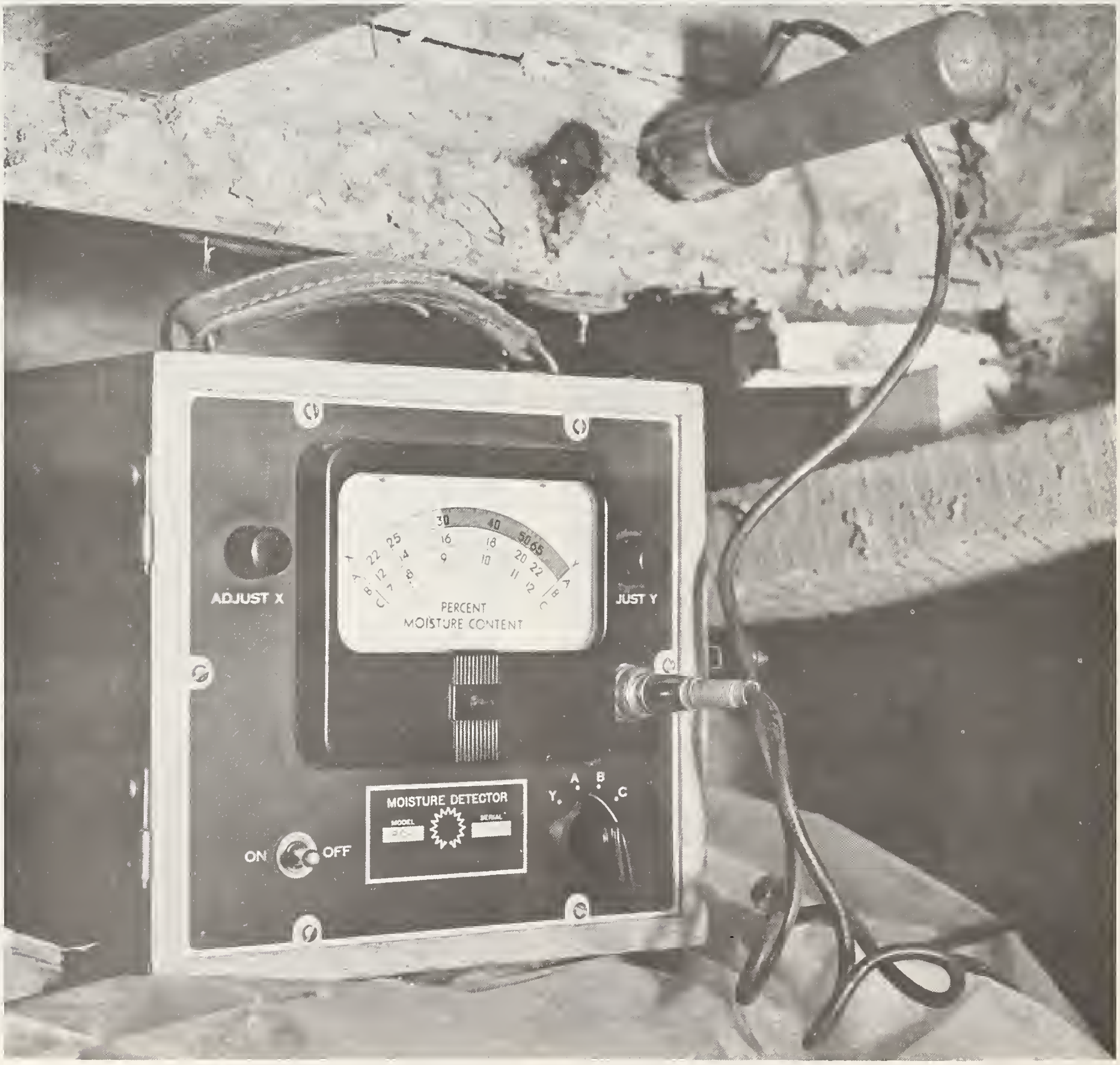

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FIGURE 10.—Electrical resistance moisture meter used to measure moisture in wood.

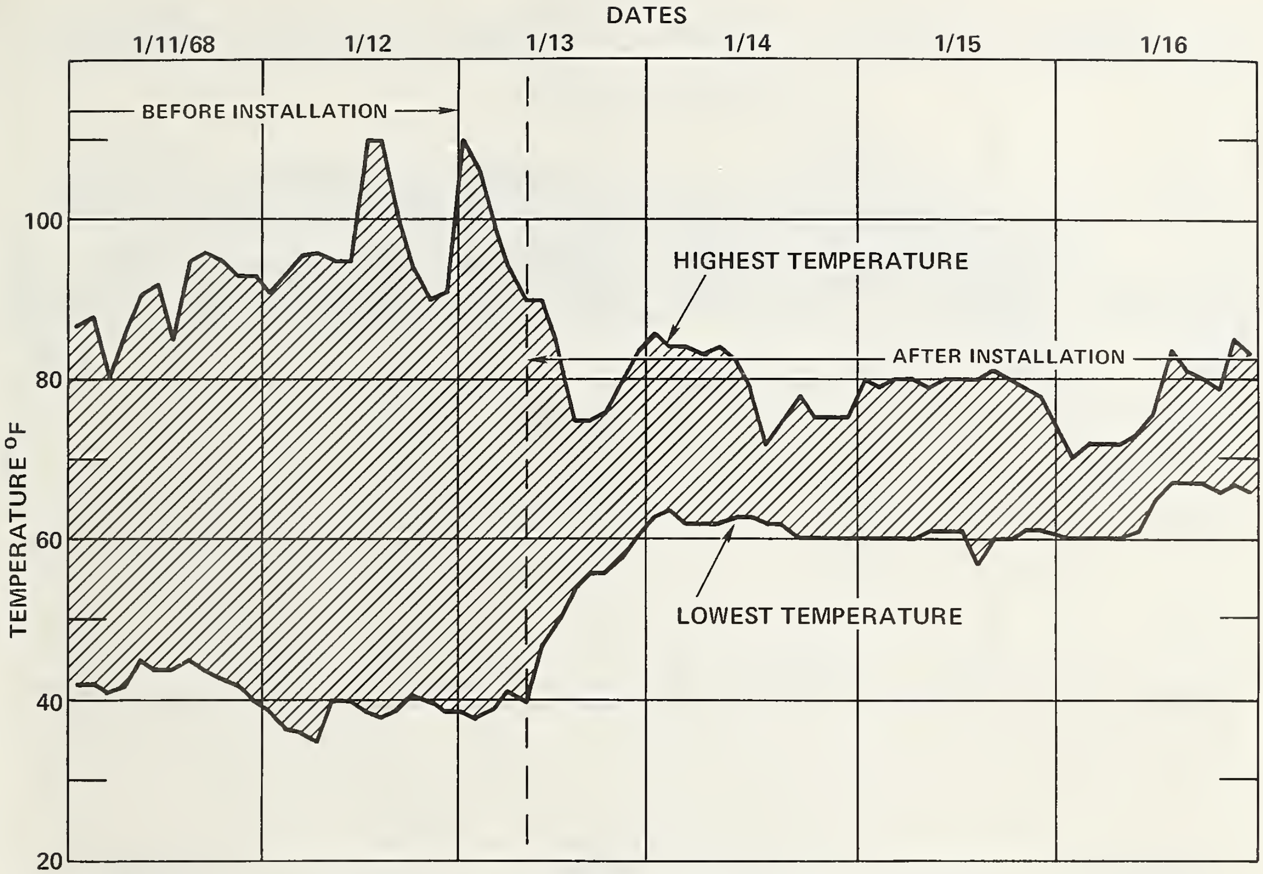


FIGURE 11.—Plot of recorded temperatures in testhouse before, during, and after installation of peripheral circulation system.

room above the heater were as much as 110°, or a 70° difference.

On January 13 the fan was started at 11:30 a.m. There was an immediate drop in the ceiling temperature of the living room and a fairly rapid increase in the temperatures of the back bedroom. Twelve hours after the blower was started, the low temperature was 60° F. and the high was 84°. Temperatures in this range continued for the next several days, when it was decided that the volume of airflow was not great enough to maintain uniform temperatures (within about 5°).

On January 16 additional holes were drilled under the shoe molding in the back bedroom. The short circuit duct was also enlarged to increase the direct distribution of heat. Again there was an immediate response to the increased volume of air. The living room ceiling temperature dropped to about 72° F., and the back bedroom temperature rose to between 68° and 70°. For the next several days temperatures were uniform, ranging between 74° and 80°.

On January 22 there was evidence that the house was occupied, because the temperatures began to fluctuate, but the variation continued to be about 6° F. On January 24 there was evidence that the blower was not operating for about 36 hours and the temperature range increased. Since this was a warm period, the maximum temperature variation in the house was only 26°. Figure 12 shows a plot of the temperature variation throughout the house during test series. From this date until January 28, temperatures remained fairly constant, again with about a 6° variation. Tests started on February 29 show a noticeable increase in

(*Continued on page 13.*)

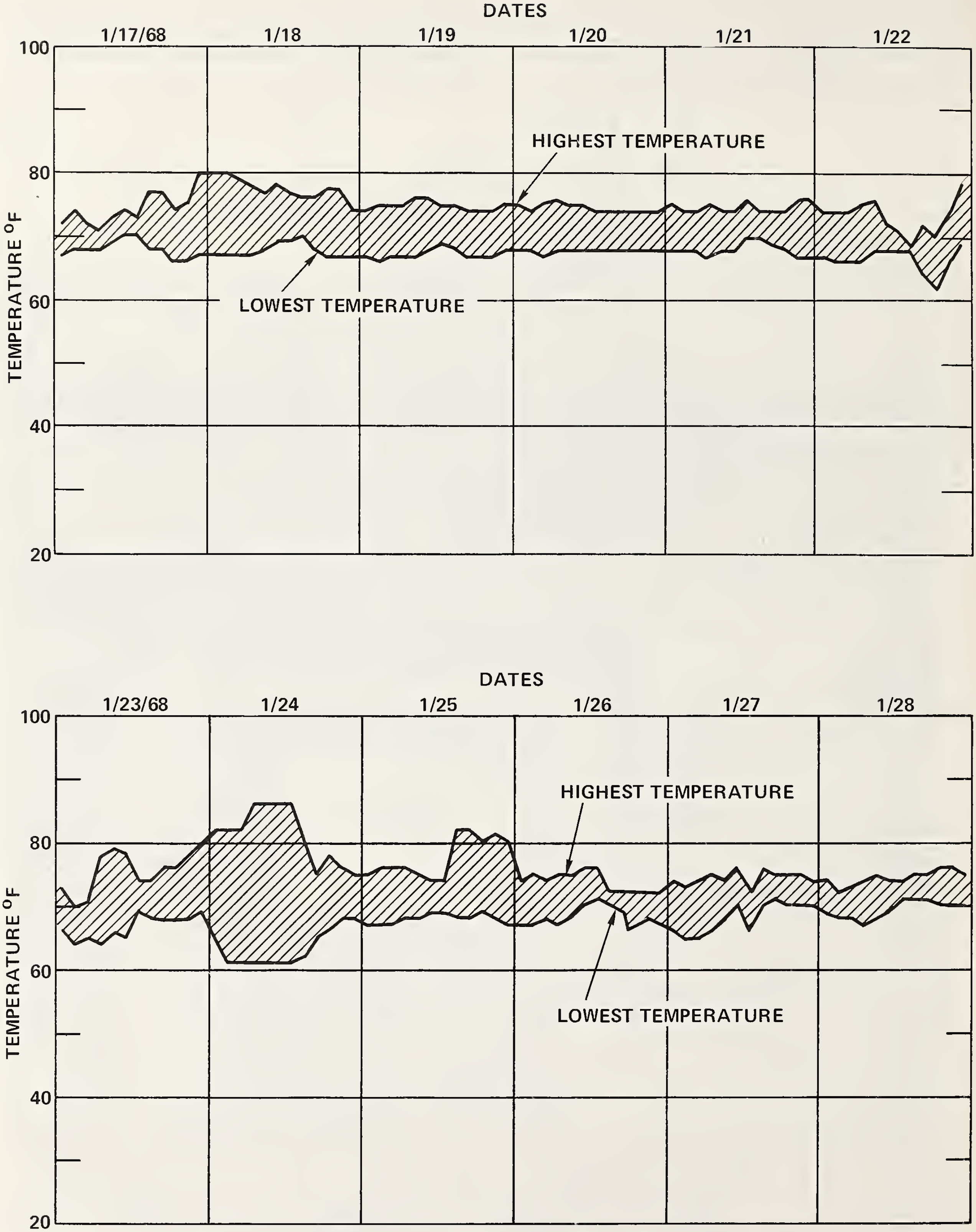
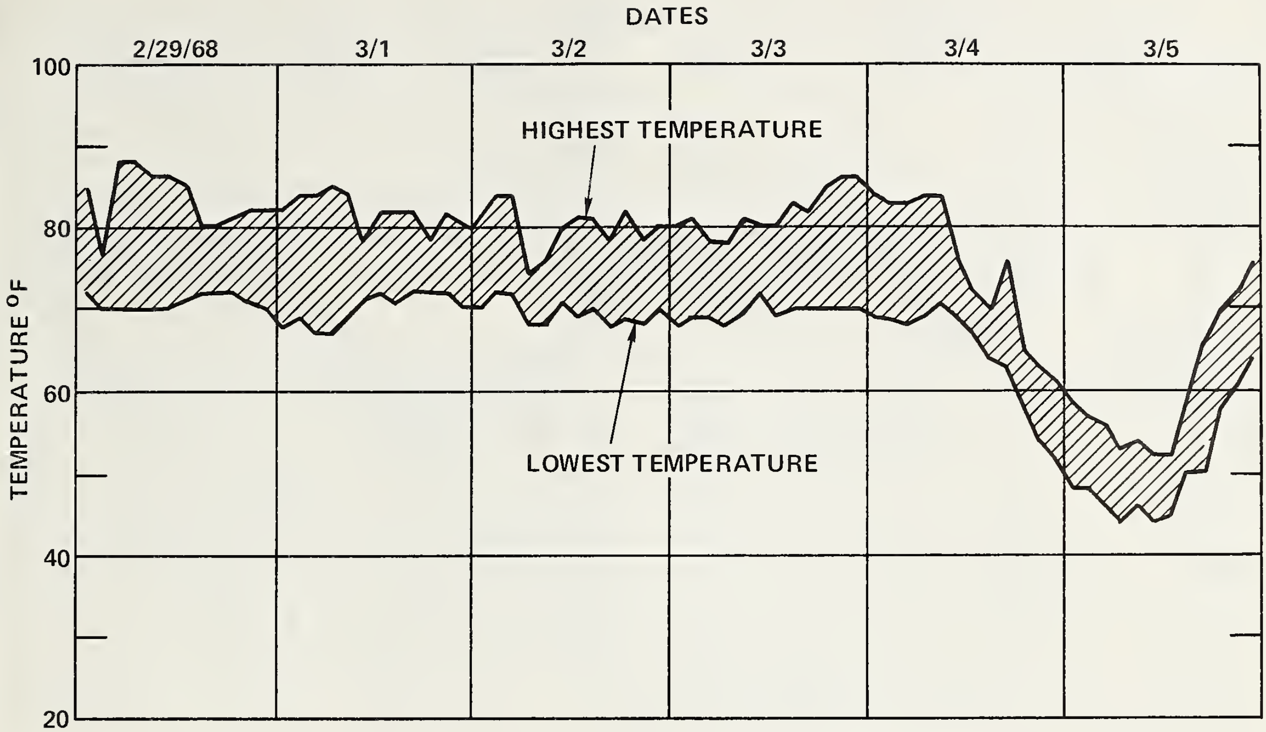


FIGURE 12.—Plot of temperature variation throughout house during test series.



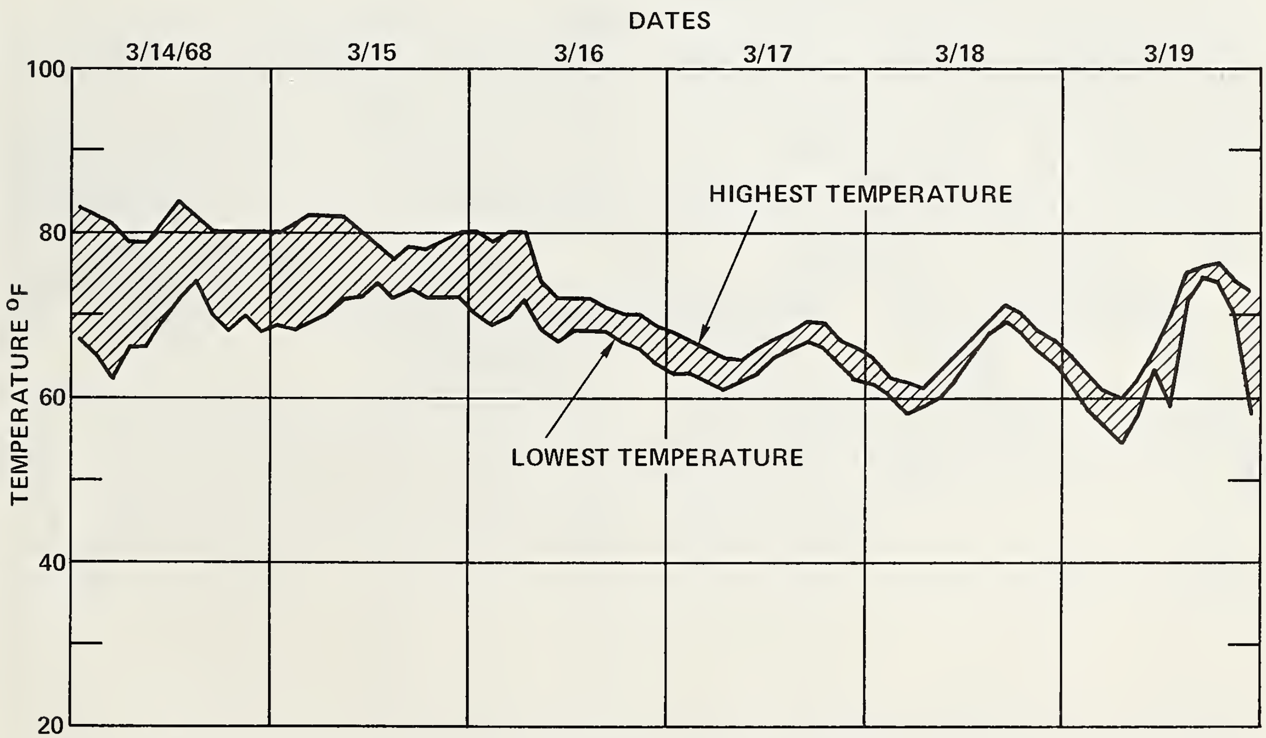
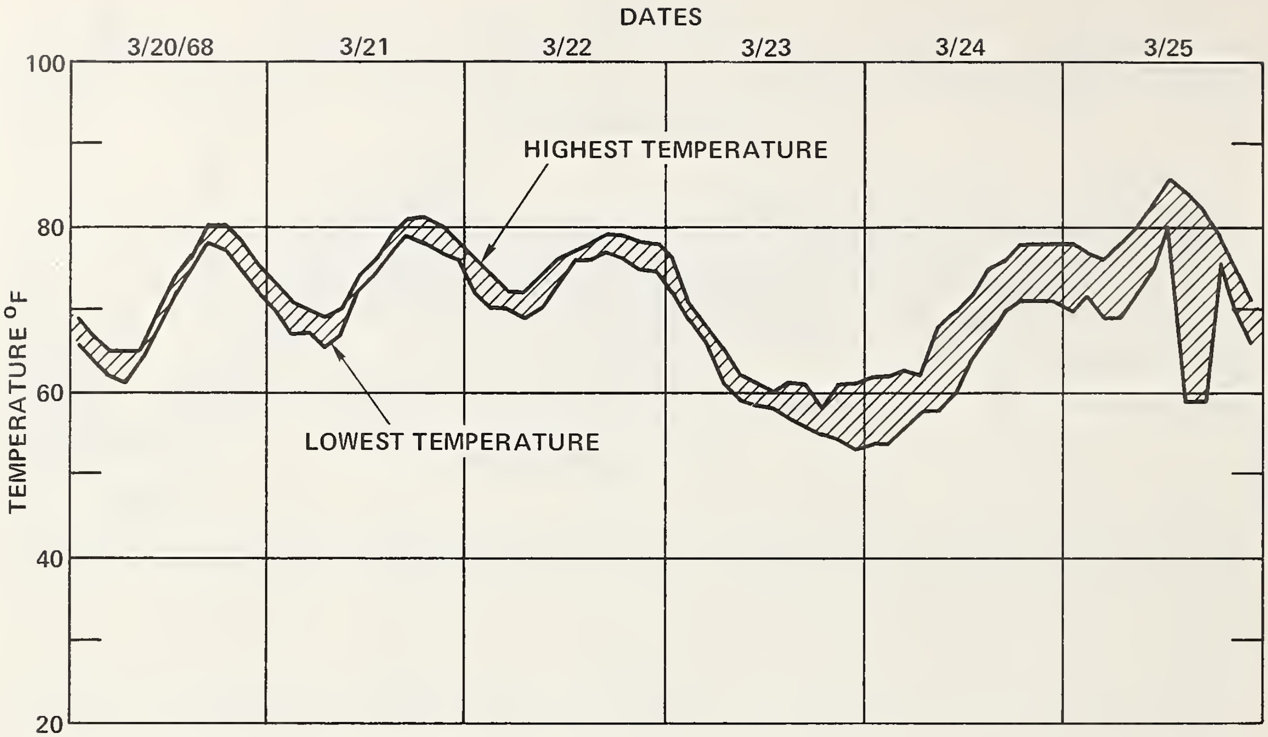


FIGURE 12.—Plot of temperature variation throughout house during test series—Continued



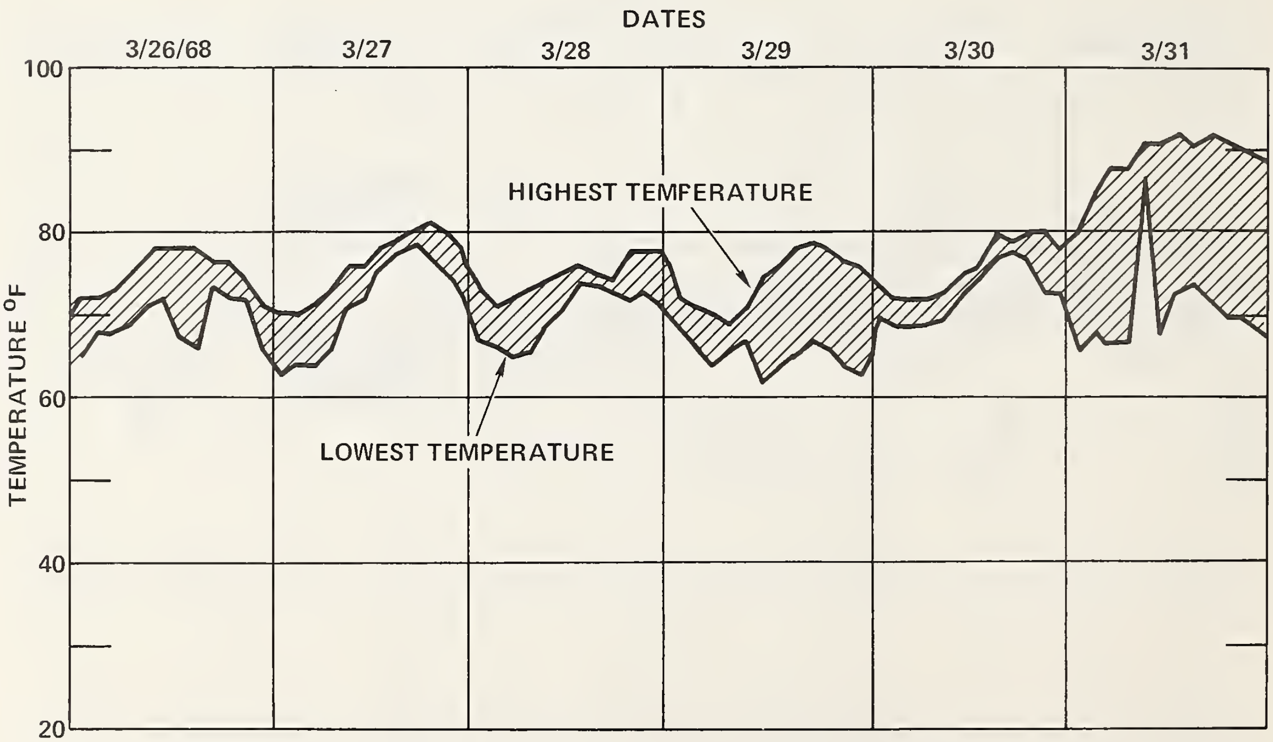


FIGURE 12.—Plot of temperature variation throughout house during test series—Continued

temperature variation. An inquiry was made, and it was found that the occupants had reset the shoe molding tight against the floor. Thus the circulation in all rooms except the back bedroom was shut off. Since the door to this room was frequently closed, heat distribution was not very effective from this date until the outside temperature began to rise in late March and early April.

Relative Humidity in Living Area

A record was made of the temperature and relative humidity in several parts of the house for several days before and after the installation of the peripheral circulation system. Figure 13 shows a plot of these readings. Examination of the plot shows that the relative humidity fluctuated, with an average reading of about 40 percent. A sudden rise in temperature would cause a sudden drop in the relative humidity.

TABLE 1.—*Moisture content of crawl space timbers*

Date in 1968	Moisture reading: Under bathroom	Moisture reading: Under living room	Moisture reading: Under back bedroom
	Percent	*Percent*	*Percent*
January:			
3	18	22	49
12	11	19	26
14	7½	9	21
19 [1]	7	7	25
22		7½	14
25	(2)	7	9
27	(2)	7	10
29	(2)	7	10
31	(2)	7	9.5
February:			
3	(2)	7	9.2
7	(2)	(2)	8.8
10	(2)	(2)	7.5
14	(2)	(2)	7.5

[1] Snow melting.
[2] No indication of moisture.

Moisture Content of the Timbers in Crawl Space

The initial investigation of the house showed that timbers in the crawl space were dripping wet in places, and an abundance of fungi was growing. The initial moisture content of the timbers ranged from 18 to 49 percent. Table 1 shows a series of moisture readings of several different locations in the crawl space. On January 22 the moisture content of all the timbers had dropped below 15 percent, which is an acceptable level. Readings taken after January 22 showed that the moisture content continued to drop until February 10, when it was less than 8 percent in all locations. There was a drop in moisture content of timbers between January 3 and January 12 because the system was operated off and on during installation.

SUMMARY

This study proved that peripheral circulation can be easily and economically installed in houses with crawl spaces. Temperature records showed that the variations in temperatures were effectively reduced from an intolerable difference of 70° F. to a comfortable 5° to 7° range.

Wet, unsanitary crawl spaces can be effectively dried out and maintained in good condition by the proper circulation of warm air. Heat can be effectively distributed without undesirable drafts.

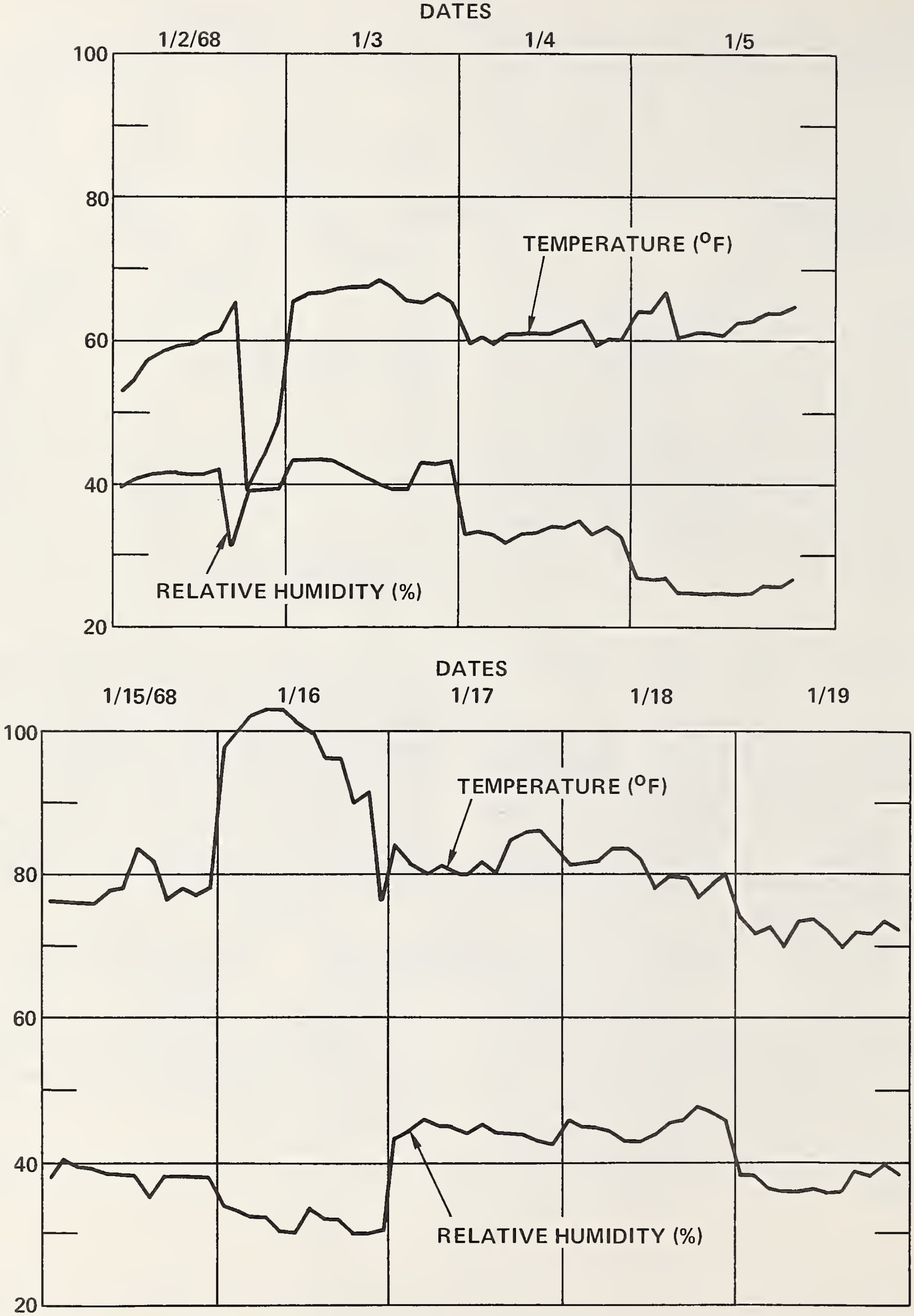


FIGURE 13.—Plot of relative humidity and temperature record in testhouse before (upper) and after (lower) installation of peripheral circulation system.

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